NOAA-GFDL and the North American Multi-Model Ensemble

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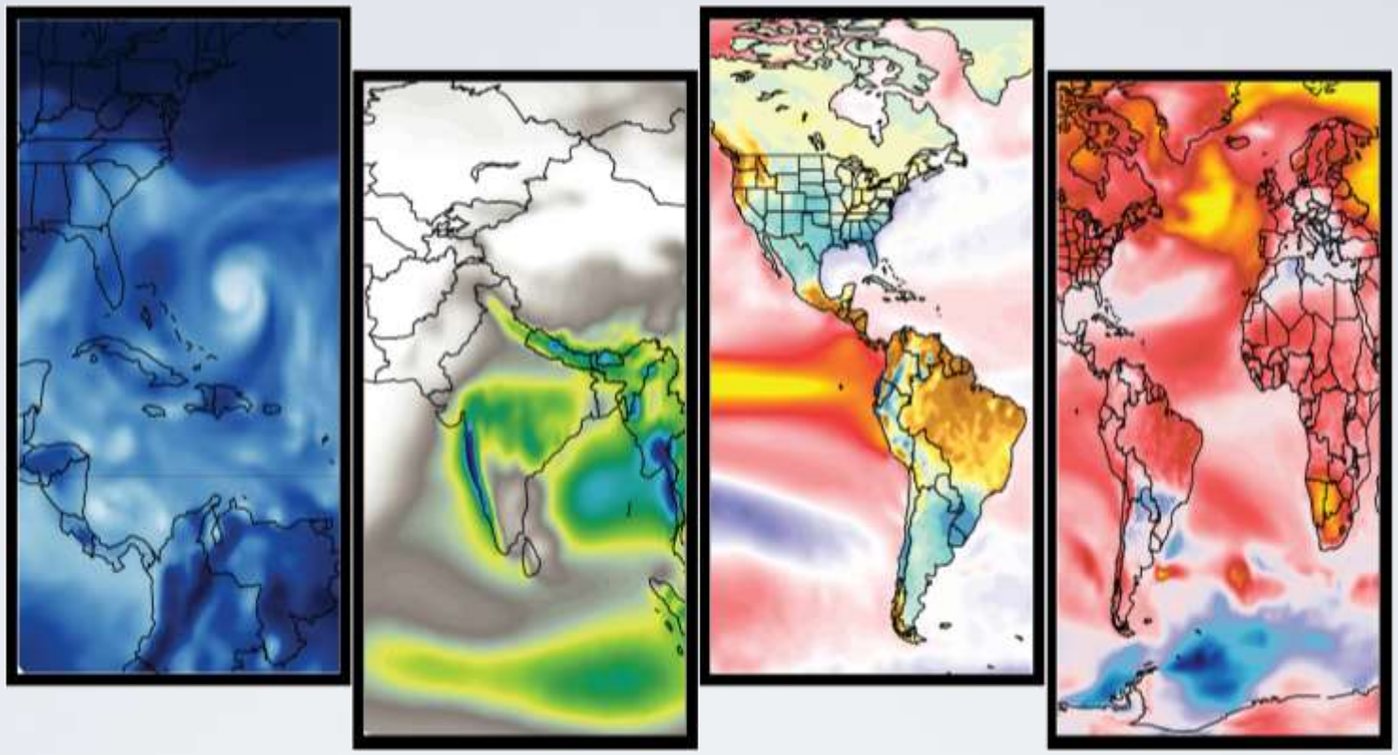


GFDL & the NMME :

- CM2.1-based forecasts since inception
- Addition of FLOR (high-resolution) to NMME in March 2014
- Contributed Phase II data from FLOR
- Ongoing Research on subseasonal predictability & prediction

Initial GFDL forecast contribution to NMME

- Built on GFDL-CM2.1 (~200x250km atmosphere/land, 1° ocean/sea ice, LM2 land model)
- Initialized using GFDL coupled ensemble kalman filter assimilation
- Has yielded exciting results thus far and will continue for some time, a world class forecast system
- Seamless intraseasonal through multi-centennial system

However:

- Relatively low resolution atmosphere: can’t directly get to extremes/regional
- Large biases (processes poorly represented)
- Representation of land processes relatively primitive

GFDL FLOR: Experimental high-resolution coupled seasonal to decadal prediction system

Goal: Build a seasonal to decadal forecasting system to:

Yield improved forecasts of large-scale climate

Enable forecasts of regional climate and extremes

Precipitation in Northeast USA

Medium resolution (CM2.1)

High resolution (CM2.5-FLOR)

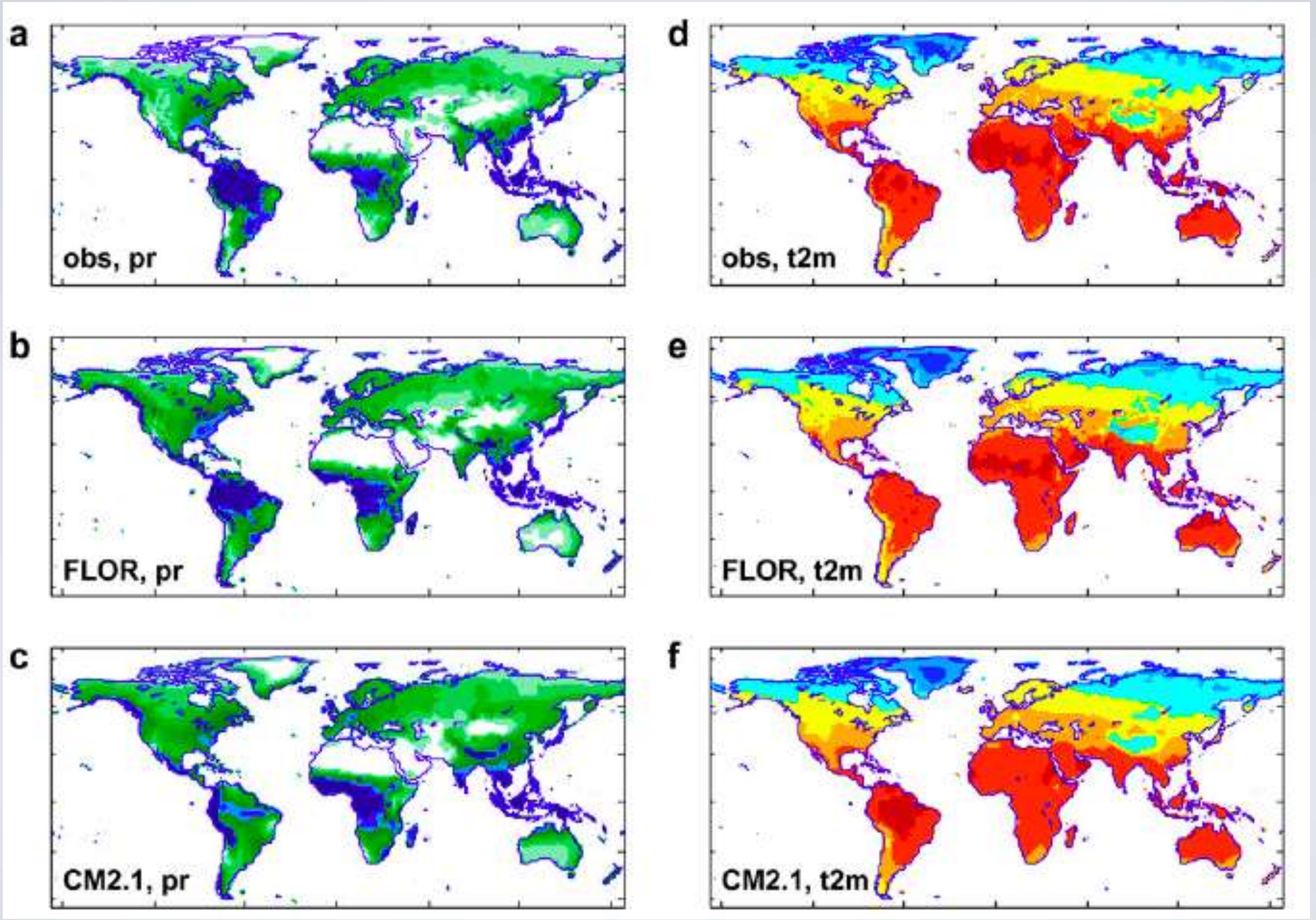
Delworth et al. (2012), Vecchi et al. (2014)

Modified version of CM2.5 (Delworth et al. 2012):

- 50km cubed-sphere atmosphere
- 1° ocean/sea ice (low res enables prediction work)

~15-18 years per day. Multi-century integrations. 4500+ model-years of experimental seasonal predictions completed and being analyzed.

FLOR improves simulation of land Ts and Pr over CM2.1



Jia et al. (2014, J. Clim.)

GFDL-FLOR to the NMME (1)

- GFDL FLOR 2014 Contribution: Two versions of FLORp1 Predictions, 12-members each: A06 and B01 – differ slightly in ocean physics (in some ways can be considered 24-member ensemble)

  CM2.1 will continue to be provided for duration of GFDL involvement in NMME.

- Ocean & sea ice initialized from CM2.1 V3.1 EnKF Assimilation

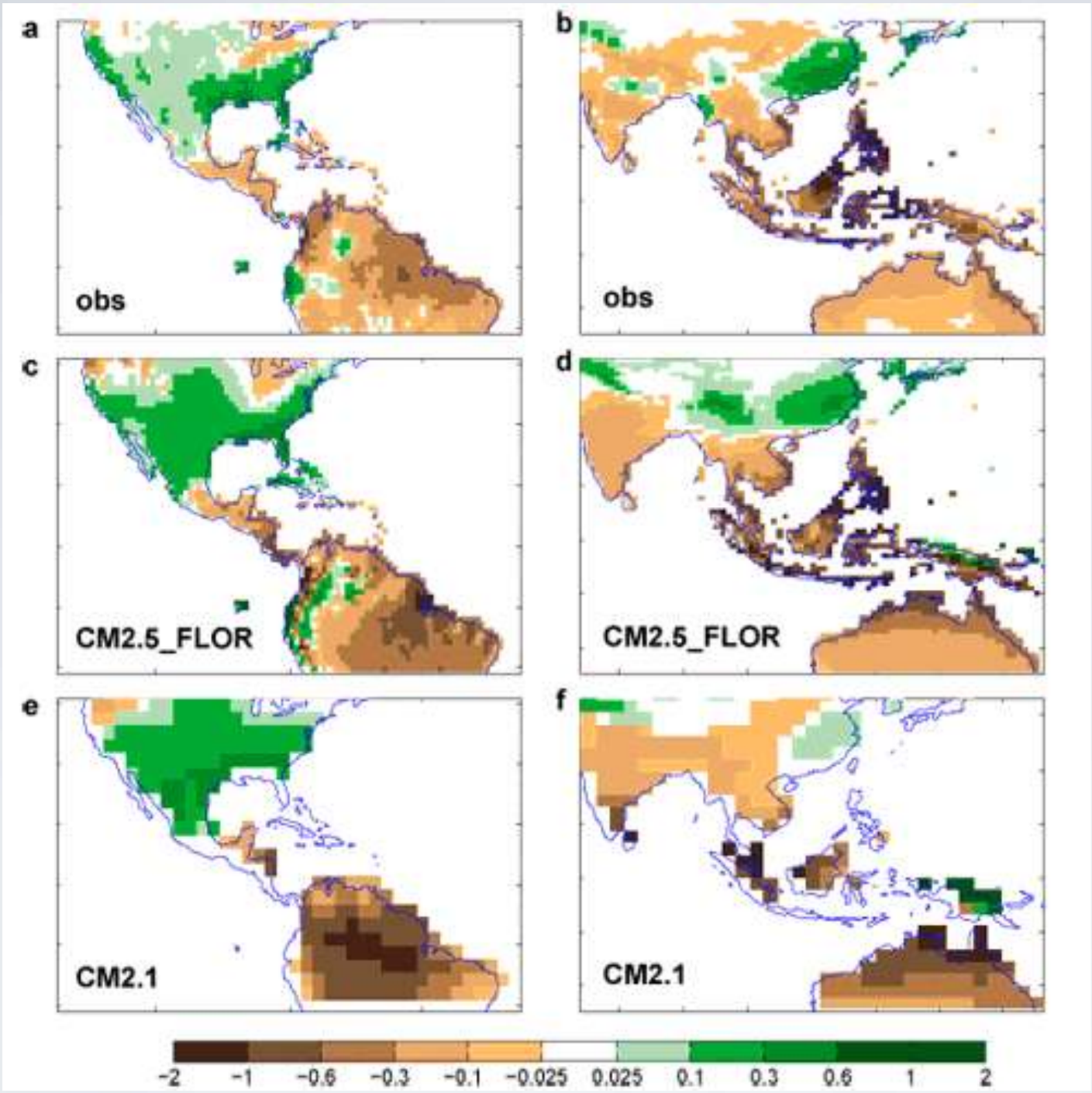
- Atmosphere and land initialized from ensemble of AGCM (*i.e.,* only information contained in SST and radiative forcing in atmos/land ICs)

- Key dates: Feb. 14 March reforecasts to NMME, March 5-8 March 2014 forecasts. Following that, will make all reforecasts available over time (need to Q.C., etc.)

- Initially, small set of variables, broadening after Q.C.: SST, t_surf, precip.

- References: Jia et al. (2014, J. Clim.), Msadek et al. (2014, J. Clim.), Vecchi et al. (2014, J. Clim.), Yang et al. (2015, J. Clim.)

Most predictable pattern in rainfall improved in FLOR

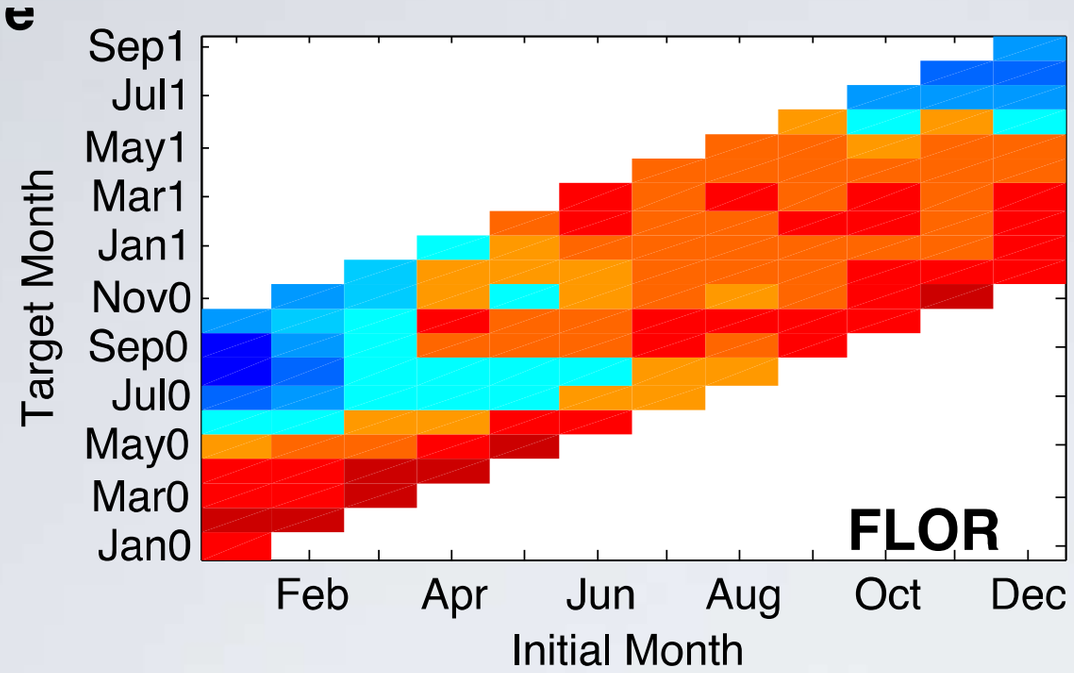


mm/day per stddev

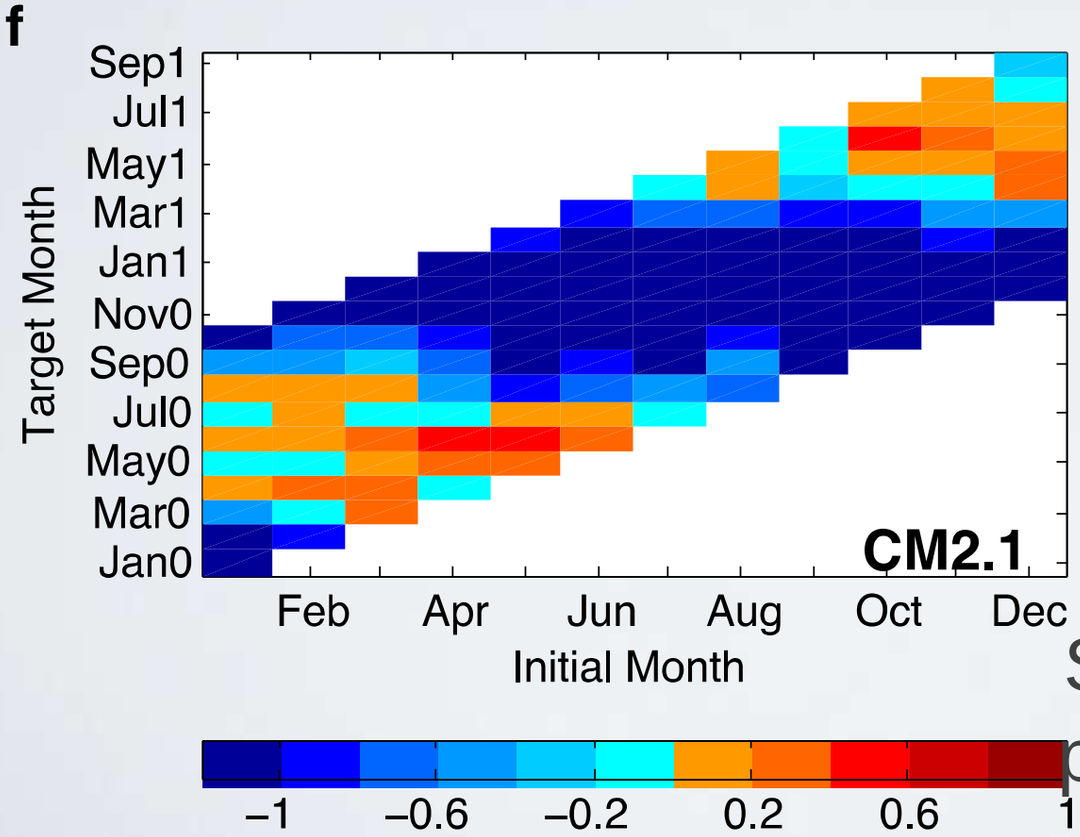
Most predictable precip pattern (mm/day)

(Ja et al. 2014, J. Clim.)

FLOR improves prediction skill of ENSO precipitation (and temperature) over land



Hi-res



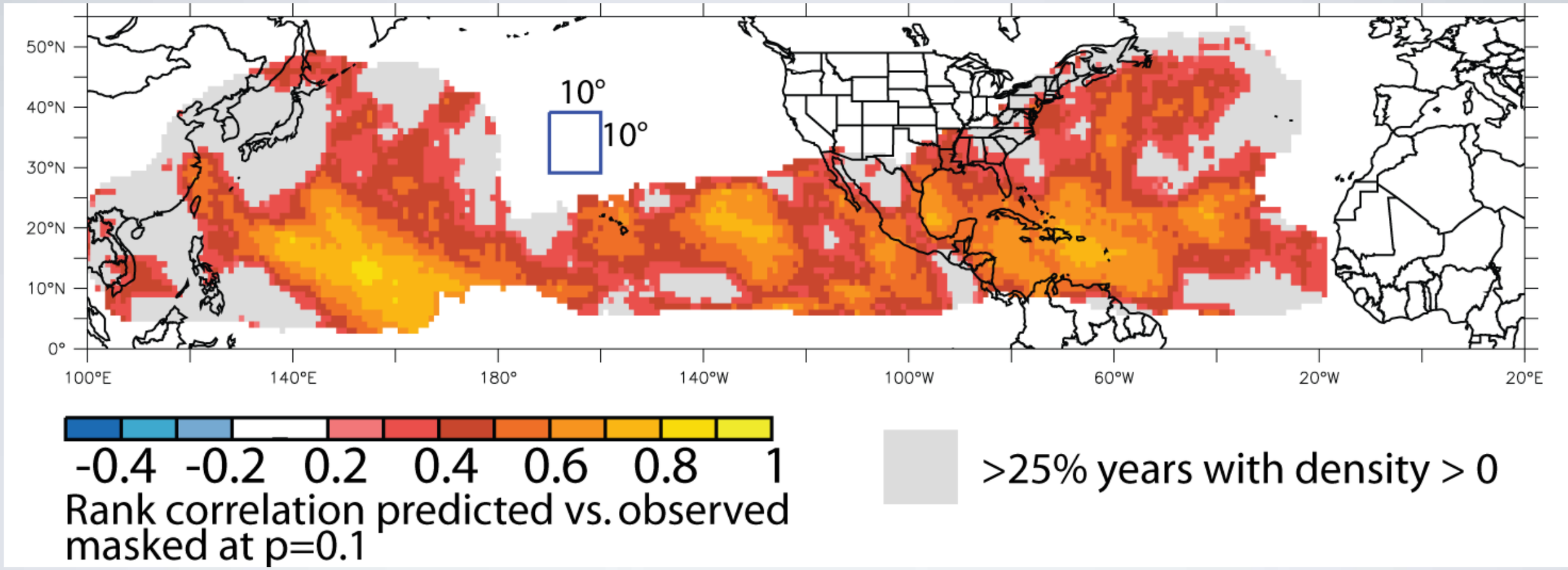
Med-res

Skill (SESS) of 1981-2012 predictions of ENSO precip

Jia et al. (2014, J. Clim.)

FLOR: Seasonal predictions of regional TC activity

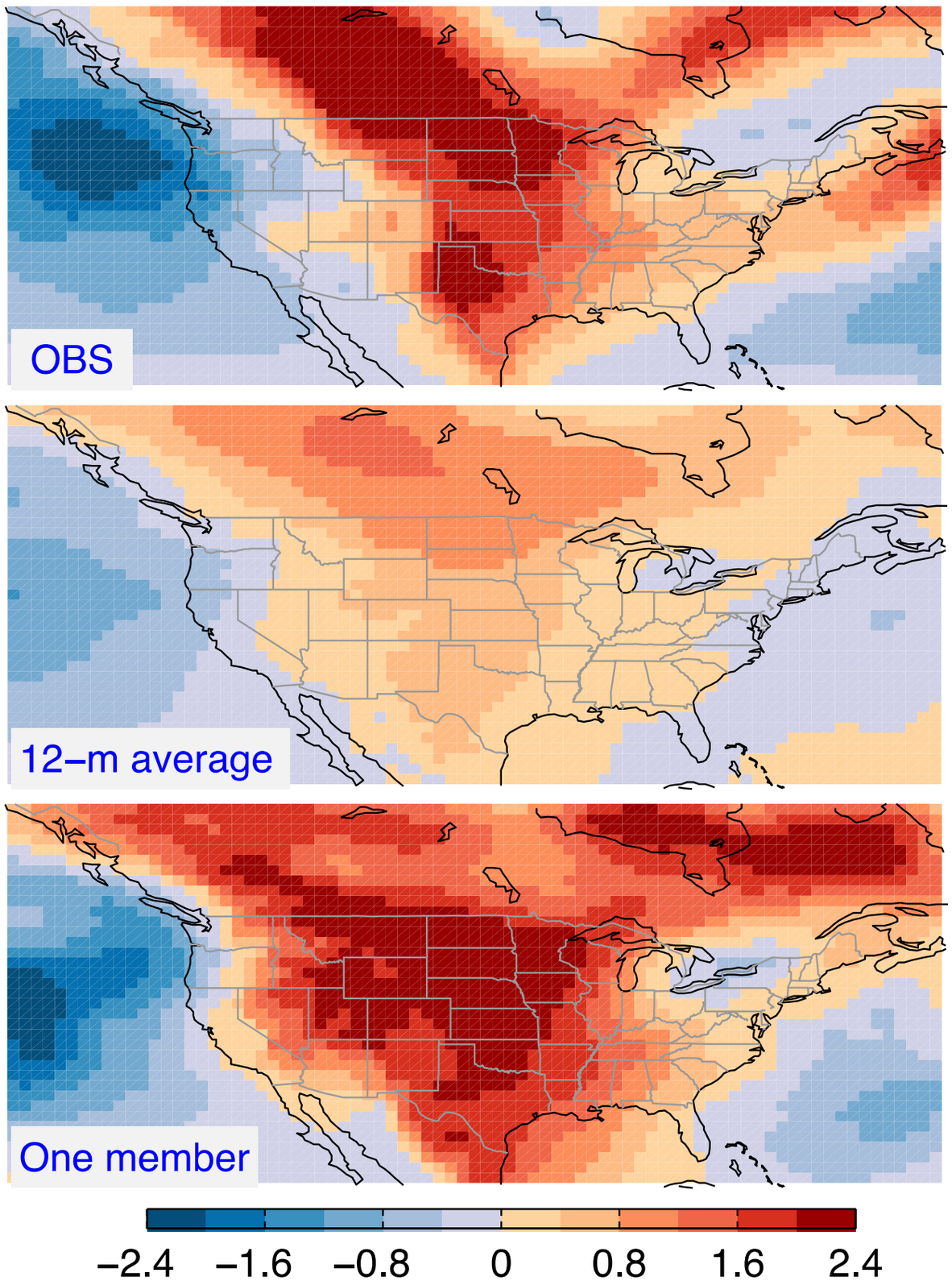
GFDL-FLOR 1981-2012 1-July Initialized Forecasts for July-December



Rank correlation: Can experimental FLOR forecasts distinguish years with many and few storms passing within 10˚ x10˚ of a point?

Vecchi et al. (2014, J. Clim.)

Skillful FLOR-based predictions of anomalous storminess over North America in winter 2013-14



Skill for regional, seasonal extra-tropical storminess over long reforecast set as well.

Yang et al. (2015, in press)

Phased approach to FLOR predictions

Phase 1	Proof of concept, assess value of high-resolution. Targets: seasonal, multi-month lead large-scale as well as regional and extremes (regional TC activity)	Use CM2.1's ocean-ice ICs, atmosphere/land from a long AMIP run. 1980-present forecasts.	Done & ongoing – first real-time forecast delivered to NMME 5-March-2014
Phase 2	Test hypothesis that atmospheric initialization improves predictions. Enable intraseasonal predictions of regional and extremes (e.g., regional TC and XTC activity, sea ice)	Nudge atmosphere to MERRA analyses, CM2.1's ocean-ice ICs, Make 1990-present forecasts. (Exploring subseasonal predictability)	Nudging run done for 1980-present, retrospective forecasts done for 1990-present, evaluating impact of constraining atmosphere.
	"Best shot" at predictions of regional and extremes, seamlessly	Build coupled assimilation on high-	Assimilation in development. Running retrospective

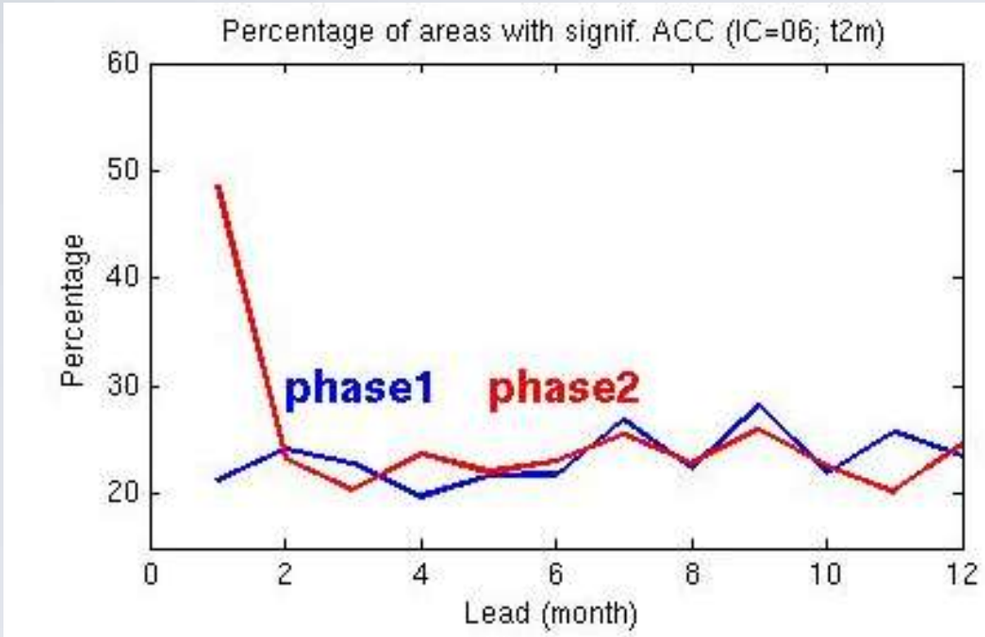
GFDL-FLOR to the NMME (2)

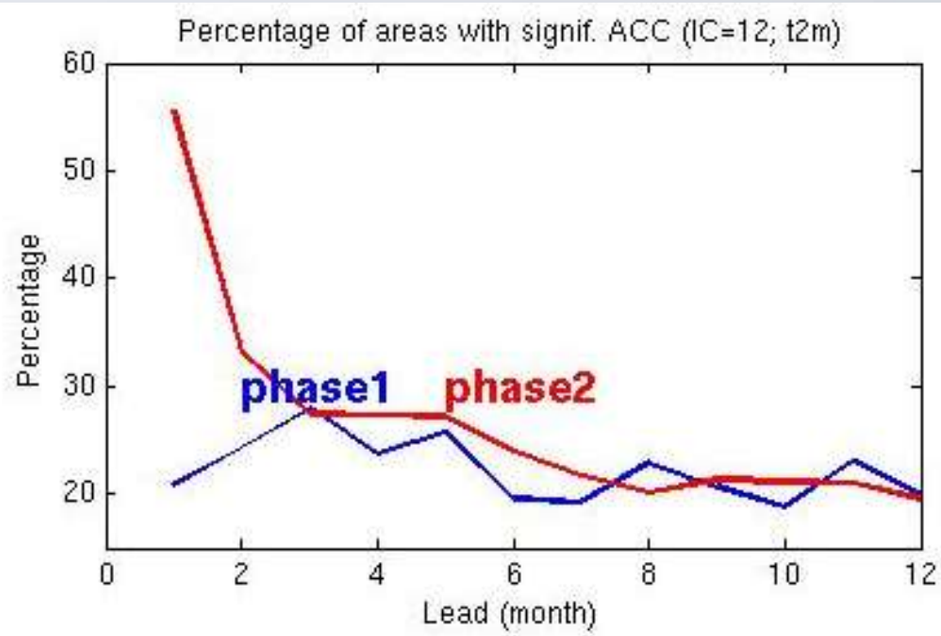
- **Initialization of GFDL FLOR P2**
  - ✓ Ocean & sea ice initialized from CM2.1 V3.1 EnKF Assimilation
  - ✓ Atmosphere and land initialized from the atmosphere-nudging-to-reanalysis AGCM simulations

    (*i.e.,* only information contained in atmosphere, SST and radiative forcing in atmos/land ICs)
- **Hindcast experiments**:
  - ✓ 1990 to present, 12 ensemble members
  - ✓ 12-month hindcasts starting first day each month
- **Computational cost for each month (Total core hours ~120,000)**
  - ✓ Data assimilation: 384x4
  - ✓ Hindcasts: 2x640x3 (CM2.1), 2x6240x9 (FLOR), 3x1952x1(AMIP-nudging)
- **Exploring the subseasonal predictability due to atmosphere component initialization**: MJO, NAO, stratosphere-troposphere interactions, et al.
- **Preliminary results of FLOR P2**: skill difference between P1 and P2, mechanism for the difference

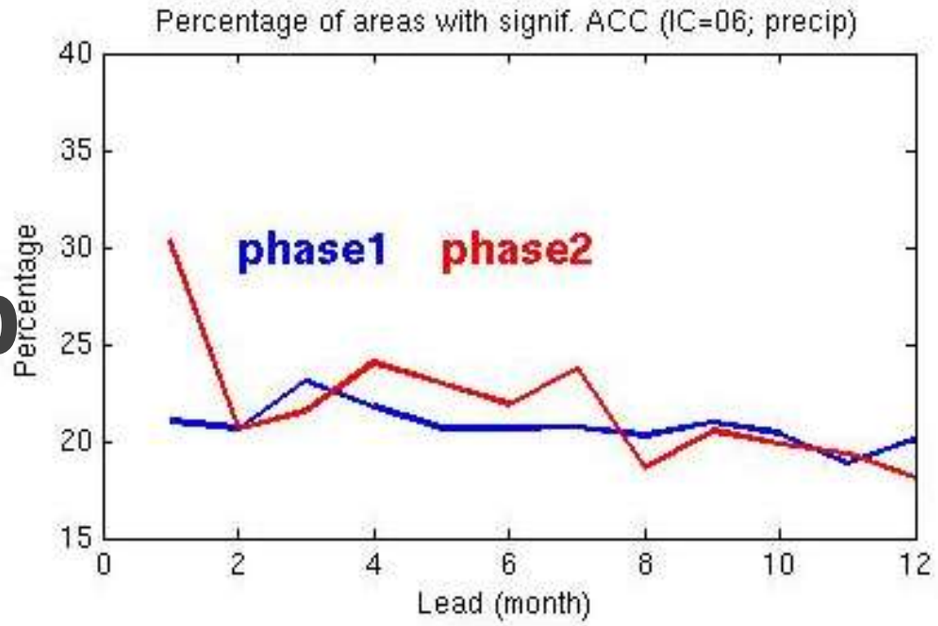
Preliminary analysis of FLOR-P2 predictions: Skill for monthly land temperature and precipitation, Role of Atm. I.C.)

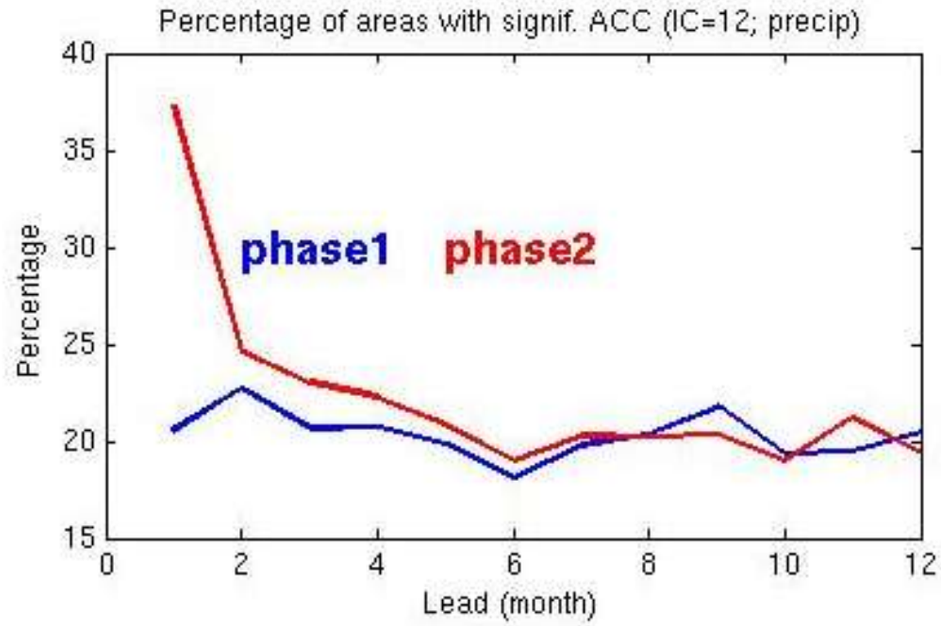
T2m





Precip





I.C.: **01Jun.**

I.C.: **01Dec.**

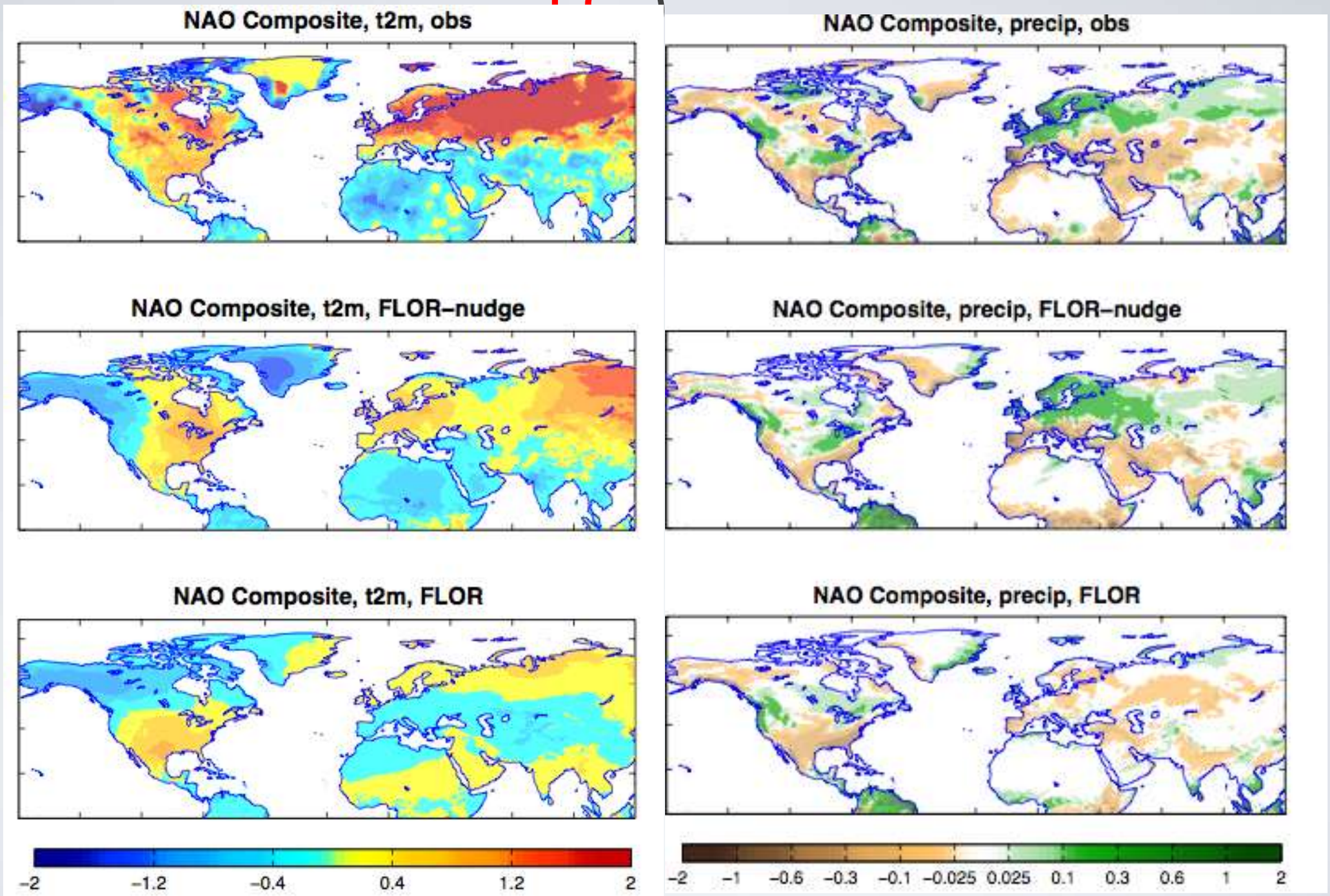
Ratio of areas with

Preliminary analysis of FLOR-P2 predictions: Subseasonal variability over land, Role of Atm. I.C.)

Obs

P2

P1



I.C.: 01Dec

T2m

DJF NAO+

Precip

GFDL Predictions and the NMME

Key foci: ENSO, hurricanes, extratropical storms, drought, sea ice, NAO, MJO

Coupled data assimilation

- CM2.1-ECDAv3.1 (1960-present)

FLOR model (50km atmosphere)

- “sweet spot” of quality, speed, readiness
- regional applications, extremes
- seamless predictions: intraseasonal to multidecadal

Groundbreaking prediction research & application

- Highest-resolution seasonal forecasts in the world
- Seasonal hurricane outlook → NOAA
- ENSO outlook → IRI
- sea ice outlook → SEARCH

Subseasonal predictability and prediction

-Evaluating subseasonal predictability in FLOR-P2

-Exploring mechanism governing skillful subseasonal prediction

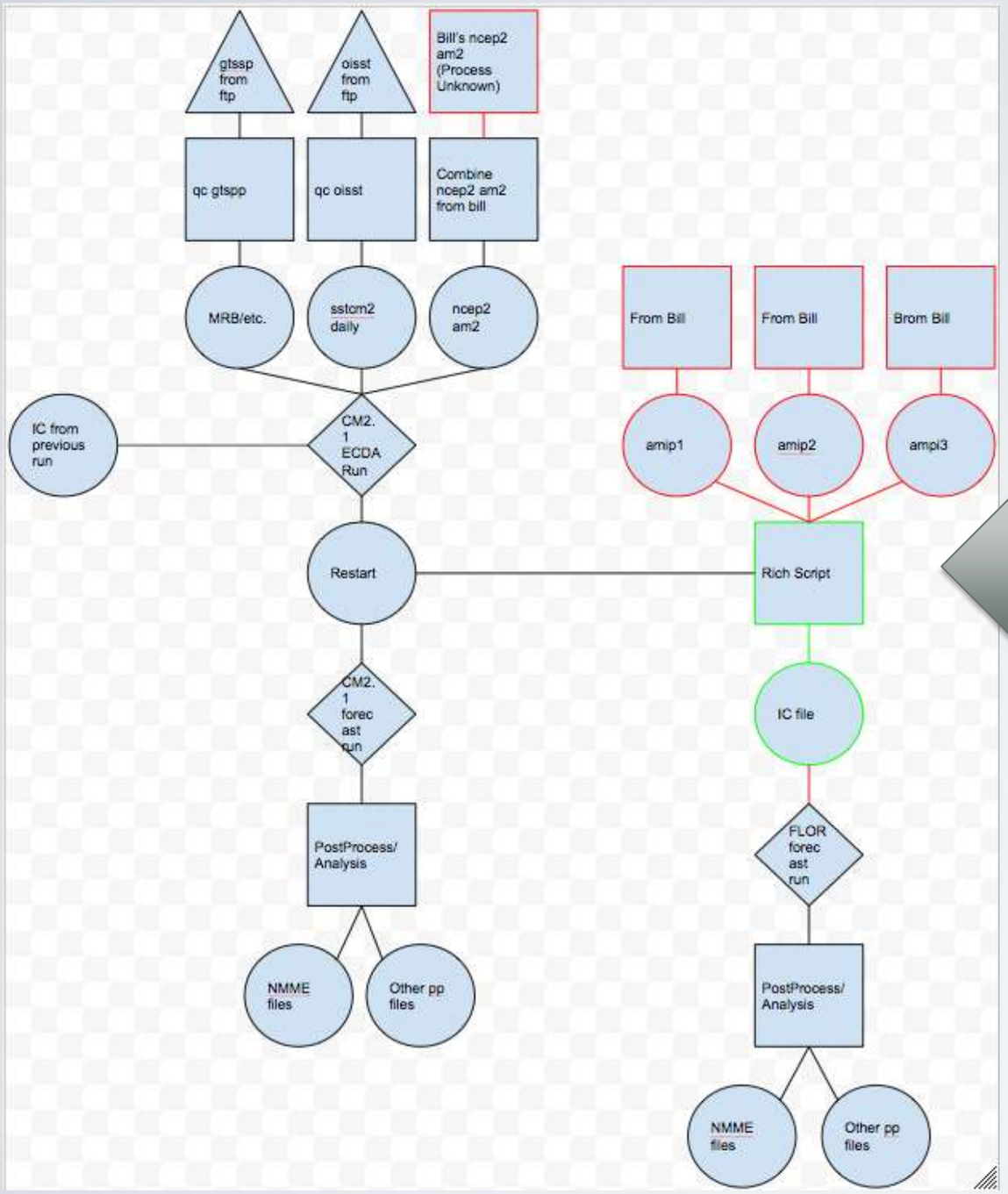
-Model (better stratosphere representation) and initialization (coupled) development for subseasonal prediction

-Readiness of FLOR-P2 hindcasts: need QCed, timescale of months

THANKS

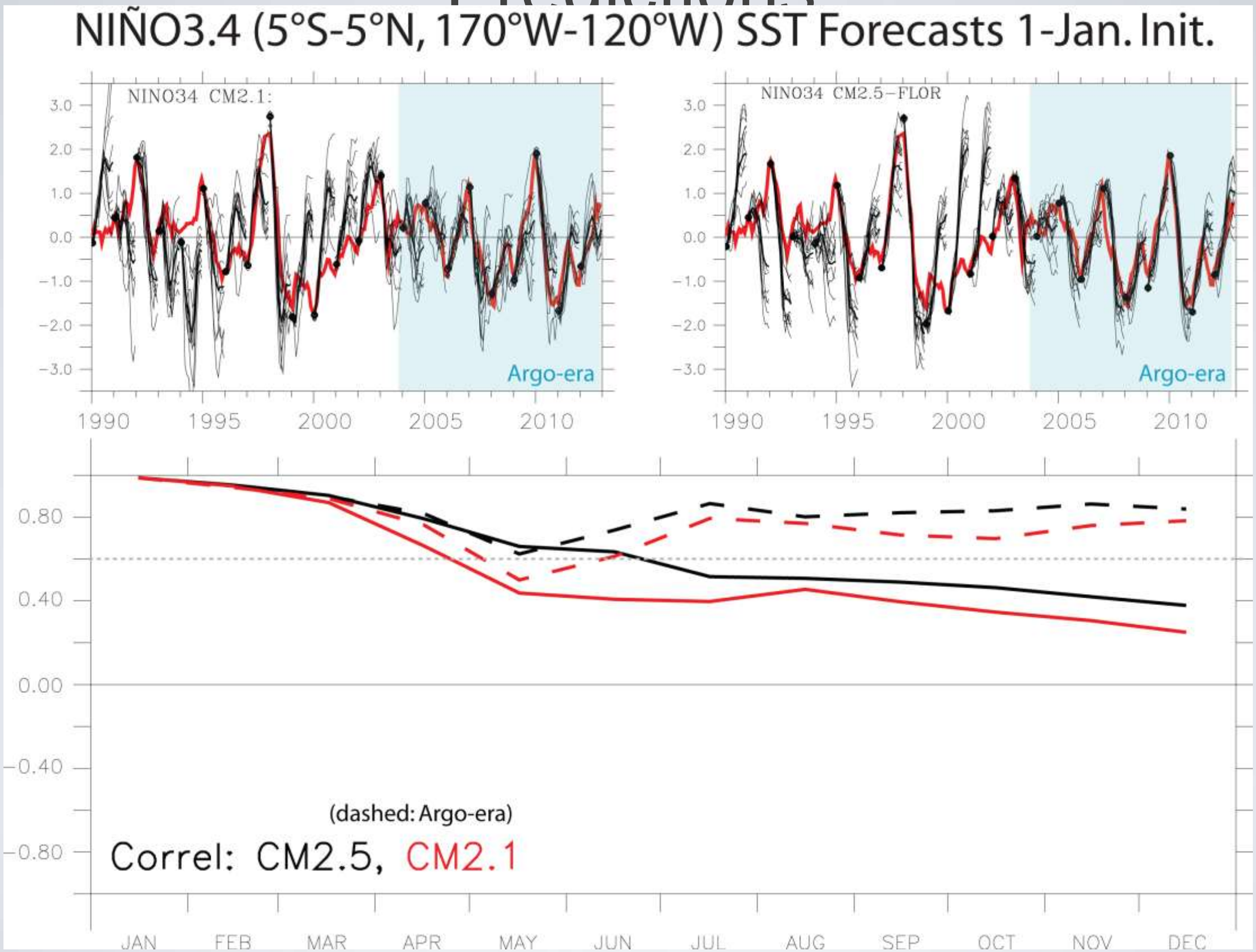
Efficient resource use: automation and focus

GFDL Prediction process: every month



- Real-time forecasts a challenge within research environment: human & computer resources as well as culture.
- Fully-automated workflow soon to be our main M.O.
  (thanks Seth Underwood!!!!!)
- We've targeted our tools to prediction problem
- NMME enables us to engage community

FLOR Improves on CM2.1 for SST Predictions



FLOR Improves on CM2.1 for SST Predictions